

RESEARCH AND RECOVERY OF  
SNAKE RIVER SOCKEYE SALMON

ANNUAL PROGRESS REPORT  
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## EXECUTIVE SUMMARY

On November 20, 1991, the National Marine Fisheries Service listed Snake River sockeye salmon *Oncorhynchus nerka* as endangered under the Endangered Species Act of 1973. In 1991, the Idaho Department of Fish and Game, the Shoshone-Bannock Tribes, and the National Marine Fisheries Service initiated efforts to conserve and rebuild populations in Idaho.

Initial steps to recover sockeye salmon included the establishment of a captive broodstock program at the Idaho Department of Fish and Game Eagle Fish Hatchery. Sockeye salmon broodstock and culture responsibilities are shared with the National Marine Fisheries Service at two locations adjacent to Puget Sound in Washington State. Activities conducted by the Shoshone-Bannock Tribes and the National Marine Fisheries Service are reported under separate cover. Idaho Department of Fish and Game monitoring and evaluation activities of captive broodstock program fish releases are also reported under separate cover. Captive broodstock program activities conducted between January 1, 1996 and December 31, 1996 are presented in this report.

On September 5, 1996, one female anadromous sockeye salmon was captured at the adult weir on Redfish Lake Creek. This fish was transferred to the Eagle Fish Hatchery where she was spawned on September 28.

Eighty-five additional female sockeye salmon from five captive broodstocks were also spawned at the Eagle Fish Hatchery in 1996. Successful spawn pairings produced approximately 109,000 eyed eggs with a mean fertilization rate of 60.5%.

Fertilization rate, as a function of adult sockeye salmon holding time at two different water temperatures, was investigated during this reporting period. Sockeye salmon were moved to chilled water (10°C) from ambient temperature water (13°C) ten months or five months in advance of 1996 spawning. Our hypothesis of equality with respect to mean fertilization rate, fecundity, fish length, and fish weight between temperature-time groups was not rejected at the 0.05 significance level.

Approximately 13,500 juvenile sockeye salmon were supplemented to Stanley Basin waters in 1996. On May 2, 1996, 11,545 age 1 smolts (brood year 1994) were released directly to Redfish Lake Creek, downstream of the outmigrant weir. On October 7, 1996, 1,932 age 0 (brood year 1995) juvenile sockeye salmon were released to Redfish Lake from net pens.

Brood year 1995, age 0 sockeye salmon were used to study the potential benefit of in-hatchery live feed training on growth, following their release to net pens in Redfish Lake. At release from net pens, we identified a significant difference in growth (weight gained) between live feed-trained and untrained experimental groups. However, results were counter-intuitive and indicated that untrained fish gained significantly greater weight than live feed-trained fish.

During this reporting period, seven broodstocks and three unique production groups were in culture at the Eagle Fish Hatchery. Five of the seven broodstocks were incorporated into the 1996 spawning design. Three broodstocks were terminated following spawning.

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## INTRODUCTION

Numbers of Snake River sockeye salmon *Oncorhynchus nerka* have declined dramatically in recent years. In Idaho, only the lakes of the upper Salmon River (Stanley Basin) remain as potential sources of production (Figure 1). Historically, five Stanley Basin lakes (Redfish, Alturas, Pettit, Stanley, and Yellow Belly) supported sockeye salmon (Bjornn et al. 1968; Chapman et al. 1990). Currently, only Redfish Lake receives a remnant anadromous run.

On April 2, 1990, the National Marine Fisheries Service (NMFS) received a petition from the Shoshone-Bannock Tribes (SBT) to list Snake River sockeye salmon as endangered under the Endangered Species Act (ESA) of 1973. On November 20, 1991, NMFS declared Snake River sockeye salmon endangered. Section 4(f) of the ESA requires the development and implementation of a recovery plan for listed species. At the time of this writing, a team (appointed by NMFS) is in the process of preparing the final draft of this document.

The Idaho Department of Fish and Game (IDFG), as part of their five-year management plan, is charged with the responsibility of reestablishing sockeye salmon runs to historic areas, with emphasis placed on efforts to utilize Stanley Basin sockeye salmon and kokanee resources (IDFG 1992). In 1991, SBT, along with IDFG, initiated the Snake River Sockeye Salmon Sawtooth Valley Project (Sawtooth Valley Project) with funding from the Bonneville Power Administration (BPA). The goal of this program is to conserve and rebuild Snake River sockeye salmon populations in Idaho. Coordination of this effort is carried out under the guidance of the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), a team of biologists representing the agencies involved in the recovery and management of Snake River sockeye salmon. NMFS ESA Permit Nos. 795, 823, and 844 authorize IDFG to conduct scientific research on listed Snake River salmon.

Initial steps by IDFG to recover the species include the establishment of captive broodstocks at the Eagle Fish Hatchery in Eagle, Idaho. To date, 11 broodstocks have been established from Redfish Lake outmigrants, anadromous adults, and residual adults. Six of these broodstocks have completed their life cycle and spawned. In addition to these broodstocks, 14 distinct genetic groups have been developed and released to Stanley Basin waters from the program (Flagg and McAuley 1994; Johnson 1993; Johnson and Pravecek 1995; Johnson and Pravecek 1996).

Idaho Department of Fish and Game participation in the Sawtooth Valley Project falls under two general areas of effort: the sockeye salmon captive broodstock program and Stanley Basin sockeye/kokanee fisheries research. Activities associated with the captive broodstock program are presented in this report.

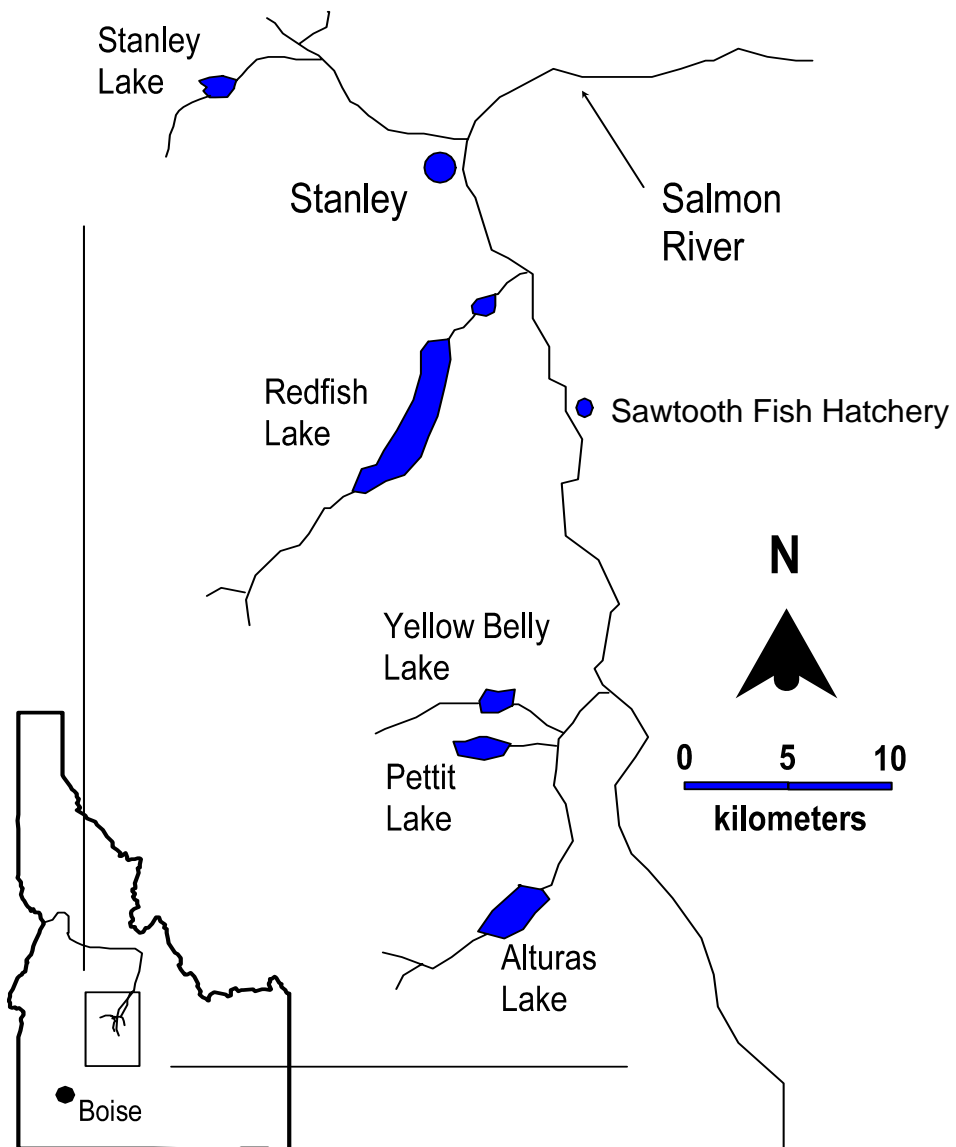


Figure 1. Stanley Basin study area.

## OBJECTIVES AND GOALS

The ultimate goal of the IDFG sockeye salmon recovery effort is to reestablish sockeye salmon runs to Stanley Basin waters and provide for the utilization of sockeye salmon and kokanee resources. The immediate project goal is to maintain Stanley Basin sockeye salmon, through captive broodstock supplementation, and avoid species extinction.

Objective 1. Develop captive broodstocks from Redfish Lake anadromous sockeye salmon.

Task 1. Develop the technology for captive broodstock propagation to meet program needs.

Task 2. Trap returning anadromous adults, juvenile outmigrants, and residual sockeye salmon.

Task 3. Quantify survival, maturation rates, age-at-maturity, sex ratio, and gamete quality of captive sockeye salmon.

Task 4. Evaluate time held on chilled water (maturing adults) in relation to gamete quality, fertilization rates, and anomalies in broodstock progeny.

Task 5. Evaluate early life history live feed training (in the hatchery) in relation to growth at release from Redfish Lake net pens.

Task 6. Evaluate sexual maturation in relation to growth rate manipulation.

Objective 2. Maximize genetic diversity within captive sockeye salmon broodstocks.

Task 1. Establish spawning matrices in consultation with NMFS and the program technical oversight committee.

Task 2. Produce genetically-defined progeny for use in multiple release strategies to Stanley Basin lakes.

Task 3. Take samples for genetic analysis from all wild sockeye salmon incorporated in the program.

Objective 3. Determine the efficacy of cryopreservation as a tool for meeting program goals.

Task 1. Cryopreserve milt from specific wild and broodstock sockeye salmon.

Task 2. Conduct fertilization trials using cryopreserved milt from captive broodstock adults.

Task 3. Maintain cryopreserved archives at three locations to spread the risk of loss from catastrophic events.

Task 4. Produce “designer broodstocks” from cryopreserved milt to broaden the genetic base in future brood years.

Objective 4. Technology transfer.

Task 1. Participate in the technical oversight committee process.

Task 2. Network with technical experts on issues related to culture and broodstock techniques, genetics, pathology and monitoring and evaluations.

Task 3. Continue efforts to develop a program management plan.

Task 4. Coordinate public information transfer with project cooperators.

Task 5. Provide written activity reports to satisfy the needs and requirements of IDFG, the technical oversight committee, NMFS, and BPA.

## **METHODS**

### **Fish Culture Facilities**

#### **Eagle Fish Hatchery**

Eagle Fish Hatchery is the primary Idaho site for the sockeye captive broodstock program. Artesian water from five wells is currently in use. Artesian flow is augmented through the use of four separate pump/motor systems. Water temperature remains a constant 13.3°C and total dissolved gas averages 100% after degassing. Water chilling capability was added at Eagle Fish Hatchery in 1994. Chiller capacity accommodates incubation, a portion of fry rearing and a portion of adult holding needs. Backup and system redundancy is in place for degassing, pumping, and power generation. Nine water level alarms are in use and linked through an emergency service operator. Additional security is provided by limiting public access and by the presence of three on-site residences occupied by IDFG hatchery personnel.

Facility layout at Eagle Fish Hatchery remains flexible to accommodate culture activities ranging from spawning and incubation through adult rearing. Egg incubation capacity at Eagle Fish Hatchery is approximately 180,000 eggs. Incubation is accomplished in small containers specifically designed for the program. Incubators are designed to distribute both up-welling and down-welling flow to accommodate pre- and post-hatch stages.

Several fiberglass tank sizes are used to culture sockeye from fry to the adult stage including: 1) 0.7 m diameter semi-square tanks (0.91 m<sup>3</sup>); 2) 1 m diameter semi-square tanks (0.30 m<sup>3</sup>); 3) 2 m diameter semi-square tanks (1.42 m<sup>3</sup>); 4) 3 m diameter circular tanks (6.50 m<sup>3</sup>); and 5) 4 m diameter semi-square tanks (8.89 m<sup>3</sup>). Typically, 0.7 m and 1 m tanks are used for rearing fry from ponding to approximately 1 g weight. Two and three meter tanks are used to rear juveniles to approximately 10 g and to depot and group fish by lineage or release strategy prior to distribution to Stanley Basin waters. Three and four meter tanks are used to rear fish to maturity for future broodstock production (spawning). Flows to all tanks are maintained at no less than 1.5 exchanges per hour. Shade covering (70%) and jump screens are used where appropriate. Discharge standpipes are external on all tanks and assembled in two sections ("half pipe principal") to prevent tank dewatering during tank cleaning.

#### **Sawtooth Fish Hatchery**

Sawtooth Fish Hatchery was completed in 1985 as part of the U.S. Fish and Wildlife Service Lower Snake River Compensation Plan and is located on the Salmon river, 3.5 km upstream from the confluence of Redfish Lake Creek. Sawtooth Fish Hatchery personnel and facilities have been used continuously since 1991 for various aspects of the sockeye captive broodstock program including: 1) pre-spawn anadromous adult holding; 2) egg incubation; and 3) juvenile rearing for pre-smolt and smolt releases. In addition, hatchery personnel assist with many field activities including: 1) net pen fish rearing; 2) fish trapping and handling; and 3) fish transportation and release.

Eyed eggs, received at Sawtooth Fish Hatchery from Eagle Fish Hatchery or NMFS, are incubated in Heath trays. Fry are ponded to 0.7 m fiberglass tanks. Juvenile sockeye (>1 g) are held in vats or in a series of 2 m fiberglass tanks installed in 1997. Typically, juvenile sockeye salmon reared at Sawtooth Fish Hatchery are released as sub-yearlings or yearlings. Pre-spawn anadromous adults captured at Redfish Lake Creek or Sawtooth Fish Hatchery weirs are held in vats until their transfer to the Eagle Fish Hatchery for spawning. All incubation, rearing and holding occurs on well water. Water temperature varies by time of year from approximately 2.5°C in January/February to 11.1°C in August/September. Back-up and redundancy systems are in place. Rearing protocols are established cooperatively between IDFG personnel and reviewed at the SBSTOC level.

### **Fish Culture**

Fish culture methods used in the captive broodstock program follow accepted standard practices (for an overview of standard methods see Leitritz and Lewis 1976; Piper et al. 1982; Erdahl 1994; Bromage and Roberts 1995; McDaniel et al. 1994; Pennell and Barton 1996). Considerable coordination takes place between NMFS and IDFG culture experts and at the SBSTOC level.

Fish are fed a commercial diet produced by Bioproducts® (Warrenton, Oregon). Rations are weighed daily and follow suggested feeding rates provided by the manufacturer. Through approximately 100 g weight, fish receive the manufacturer's standard semi-moist formulation. Beyond 100 g weight, fish receive the manufacturer's customized brood diet. Elevated levels of vitamin, mineral, and pigment supplementation have been included in the brood diet to improve egg quality. Palatability of the brood diet is also enhanced with natural flavors from fish and krill.

Fish sample counts are conducted as needed to ensure that actual growth tracks with projected growth. Chemical therapeutants are used as needed for prophylactic and treatment purposes. In general, fish are handled as little as possible in the program. Juvenile rearing densities are maintained at levels not to exceed 8 kg/m<sup>3</sup>. Mortalities are examined by a fish pathologist to determine cause of death. Carcasses are either incinerated, landfilled, or rendered.

### **Sexual Maturation and Growth Rate Manipulation**

Beginning in July 1995, approximately 30% of brood year 1994 broodstock progeny on-station at the Eagle Fish Hatchery (progeny of the single female sockeye salmon that returned to Redfish Lake Creek in 1994) were separated from the general population and placed on a program of reduced feeding (75% of normal broodstock feed rate). Thorpe (1986 as cited by Swanson 1995) proposed that maturation is initiated if a set-point in growth rate is exceeded at a particular time of year. Typically, broodstock sockeye salmon mature in their third year of culture. By reducing feed rate, we hypothesized that maturation could be delayed to age 4 (brood year 1998). Spreading maturation over a two-year period will help distribute critical genetic information, augment spawning designs, and decrease the potential of inbreeding. This work is ongoing and will be evaluated following first year spawning in 1997.

### **Spawning at Eagle Fish Hatchery in 1996**

Spawning has occurred at Eagle Fish Hatchery each year since 1994. Prior to 1994, adult sockeye returns were spawned at the Sawtooth Fish Hatchery (Johnson 1993; Johnson and Pravecek 1995; Johnson and Pravecek 1996). Spawning follows accepted, standard practices as described by McDaniel et al. (1994) and Erdahl (1994). Idaho Department of Fish and Game is required by NMFS Permit No. 795 to discuss proposed broodstock spawning matrices prior to conducting activities (Appendix A). In general, eggs produced at spawning are divided into three lots (by female) and fertilized with sperm from two males. Eggs are incubated by lot at different water temperatures to yield lineage-specific size groups for supplementation under different strategies and for future broodstock purposes.

### **Pre-Spawn Adult Time on Chilled Water**

Chilled water capability at Eagle Fish Hatchery was added in 1994. Beginning in that same year, adult broodstock sockeye salmon were moved to 10°C water from ambient 13°C water for part of their final maturation year. In 1995 and 1996, these efforts were continued to determine if rearing water temperature affects egg development, egg quality, fertilization rate, and percent maturation. In December 1995, one half of the ANBY93 broodstock sockeye on station at Eagle were transferred to 10°C chilled water. Fish were reared at this temperature through spawning in 1996 (approximately 10 months). The remaining pre-spawn adult ANBY93 broodstock fish were moved to 10°C chilled water in May, approximately five months in advance of spawning. A complete description of specific broodstocks follows.

Student's T tests ( $\alpha = 0.05$ ) were used to test for differences in mean fertilization rate (percent eye-up), fecundity, length, and weight between ten-month and five-month time on chilled water groups of fish.

### **Milt Cryopreservation in 1996**

Cryopreservation of milt from male donors has been carried out in the captive broodstock program since 1991 and follows techniques described by Cloud et al. (1990) and Wheeler and Thorgaard (1991). Beginning in 1996, cryopreserved milt was used to produce specific lineage broodstocks for use in future spawn years. "Designer broodstocks" produced in this manner will increase the genetic variability available in future brood years.

In 1996, cryopreserved milt from the single male that returned to Redfish Lake in 1992 was used to fertilize sub-lots of eggs produced by four unique female sockeye salmon.

In 1996, fresh milt produced from ANBY93 and OMBY93 male sockeye salmon was cryopreserved at the Eagle Fish Hatchery, Washington State University (WSU), and the University of Idaho (UI). Cryopreservation responsibilities are shared among facilities to spread the risk associated with storage system failure. Similar techniques are adhered to at each facility.

In 1996, fertilization trials were conducted at the Eagle Fish Hatchery, WSU, and UI, using fresh kokanee milt and eggs and cryopreserved sockeye salmon milt. Cryopreserved milt used for trials was preserved in 1996 as described above.

### **Fish Health Investigations in 1996**

A total of 108 cases involving 260 fish were processed through the IDFG Eagle Fish Health Laboratory for calendar year 1996 (includes 1996 spawner information). Routine fish necropsies included investigations for virus (infectious pancreatic necrosis and infectious hematopoietic necrosis - 138 fish samples), bacterial kidney disease (BKD) by enzyme-linked immunosorbent assay (ELISA) in 260 fish samples, and cold water disease in 22 fish samples. In addition, histology samples of kidney, spleen, liver, and posterior intestine were prepared by IDFG personnel at the Eagle Fish Health Laboratory from selected adult sockeye mortalities. Samples were shipped to Elizabeth MacConnell at the U.S. Fish and Wildlife Service Bozeman Fish Culture Development Center to investigate possible cause of death. Several frozen tissue and histological preparations of thymic and systemic lymphosarcomas (tumors) from adult sockeye were sent to Dr. Paul Bowser at the Cornell University School of Veterinary Medicine to determine whether tumors were associated with viral etiology.

### **Anadromous and Residual Adult Sockeye Salmon Trapping in 1996**

The anadromous adult trap on Redfish Lake Creek is located approximately 1.4 km downstream from the outlet of Redfish Lake. In 1996, the trap was operated from July 17 to October 17 and checked daily by IDFG personnel.

A floating Merwin trap is used to capture residual sockeye salmon adults in Redfish Lake. When used, the trap is installed in October on the west side of the lake at the north end of Sockeye Beach. In 1996, the residual adult trap was not installed.

### **Live Feed Training of Brood Year 1995 Juvenile Sockeye Salmon**

At the recommendation of SBSTOC, IDFG, and SBT, personnel conducted an experiment to determine whether growth of brood year 1995 sockeye salmon sub-yearlings in Redfish Lake net pens could be influenced by live feed training in the hatchery prior to introduction to net pens. Brood year 1995 represented an ideal opportunity to conduct the experiment, as fewer than 2,000 juveniles were available for net pen rearing. Beginning at first feeding, we designated two fry groups of roughly 1,000 fish each. For 30 days immediately following swim-up, *Artemia* nauplii were distributed to one group while the second group received only the standard pelletized diet. *Artemia* feeding replaced one of eight hourly pellet feedings. *Artemia* nauplii were introduced to the water system using a drip design. Approximately 1,000,000 nauplii were introduced over a 15-min period. Thirty days in advance of releasing fish to net pens, the group originally fed *Artemia* nauplii was fed adult *Artemia*, bloodworms, and glass worms for a second 30-day period. Live prey feeding replaced one of four daily feedings at this time. At the time of release into the net pens, 30 fish from each group (referred to as experimental groups) were weighed (to the nearest 0.1 g), measured for fork length (to the nearest mm), and released to separate net pens. Remaining fish (referred to as the production group) were distributed to a third net pen. Both experimental and production groups remained in the net pens until release on October 7, 1996. Experimental groups were not fed a supplemental pelletized diet. The production group was fed the standard pelletized diet at a rate of 1.5% of their body weight daily. Immediately prior to release from net pens, all experimental fish were measured for fork length and weight. A sub sample of 100 production fish

was also measured for fork length and weight. Experimental and production fish were 100% PIT-tagged prior to release to net pens.

Student's T tests ( $\alpha = 0.05$ ) were used to test for differences in fish growth (weight and length gain) between live feed-trained and untrained experimental groups for the 12 week period of net pen holding.

### **Eyed-Egg and Fish Supplementation in 1996**

#### **Egg Shipping and Fish Transportation**

Eggs are shipped at the eyed stage between NMFS and IDFG facilities using a commercial air service. Iodophor- (100 ppm) disinfected eggs are packed at a conservative density in perforated tubes, then capped and labeled. Tubes are wrapped with hatchery water-saturated cheese cloth and packed in small coolers. Ice chips are added to insure proper temperature maintenance and coolers are sealed with packing tape. Idaho Department of Fish and Game and NMFS personnel are responsible for shuttling coolers to air terminals.

Containers used to transport fish vary by task. In all cases, containers of the proper size and configuration are used for the task at hand. Fish are maintained in water of the proper quality (temperature, oxygen, chemical composition) as much as is possible during the handling and transfer phases of transportation. Containers vary from five-gallon plastic buckets and coolers for short-term holding and inventory needs to truck-mounted tanks for long distance (or duration) transfers. Truck-mounted tanks with capacities of 300 gal (1,136 L), 1000 gal (3,785 L), and 2,500 gal (9,463 L) are available to the program. Transport densities guidelines are in place to not exceed 89 g/L (0.75 lb/gal).

#### **Supplementation Strategies**

To date, sockeye salmon have been reintroduced to Stanley Basin waters as eyed eggs, sub-yearlings, yearlings, and pre-spawn adults.

Eyed eggs are distributed to egg boxes manufactured by IDFG personnel specifically for this program. Plastic light baffle grids and plastic mesh netting partition and prevent eggs from falling into the bio-filter ring medium until after hatch. Plastic mesh netting surrounding egg boxes allows fish to volitionally emigrate following yolk absorption. Egg boxes accommodate approximately 5,000 eggs each. Following loading, egg boxes are lowered to the lake substrate in approximately 3 m of water over known or suspected areas of lake shore spawning.

Sub-yearling sockeye salmon are distributed to Stanley Basin lakes using truck-mounted transportation tanks. Fish introduced directly to lakes are released at public access points at dusk. Sub-yearlings distributed to net pens are transferred from truck-mounted tanks to aerated coolers. Coolers are transported to net pens by boat. Adequate water temperature tempering occurs prior to the release of fish.

Yearling sockeye salmon (smolts) are distributed to Stanley Basin waters using truck-mounted transportation tanks. To date, yearling sockeye have only been introduced to the outlet of Redfish Lake Creek downstream of the juvenile outmigrant weir. Adequate water temperature tempering occurs prior to the release of fish.

Pre-spawn adult sockeye salmon are distributed to Stanley Basin waters using truck-mounted transportation tanks. To date, adults have only been introduced to Redfish Lake. Fish are released at public access points at dusk. Adequate water temperature tempering occurs prior to the release of fish.

## RESULTS AND DISCUSSION

### Fish Culture

During the term of this reporting period, seven broodstocks and three unique production groups (described below) were in culture at the Eagle Fish Hatchery. Culture histories (growth and inventory) of selected broodstocks are presented in Appendix B. Circumstances of mortality for fish in culture during this reporting period are presented in Tables 1 and 2.

OM93 Redfish Lake outmigrant sockeye salmon captured in 1993 and cultured at Eagle Fish Hatchery to the present. The January 1, 1996 starting inventory was 13 fish. One male from this broodstock was used to fertilize one lot of eggs produced by the anadromous female sockeye salmon that returned to Redfish Lake Creek in 1996. Progeny from this cross will be maintained for future broodstock purposes. No fish remained in the broodstock at the end of the reporting period.

RESBY92 First generation progeny of adult, residual sockeye salmon captured in Redfish Lake in 1992. Progeny were produced from spawning that occurred at the Eagle Fish Hatchery in 1992. The January 1, 1996 initial inventory was three fish. One mature male was used in 1996 to fertilize eggs produced from one RESBY93 female (see description below). Progeny produced from this cross will be incorporated in 1997 supplementation efforts. No fish remained in this broodstock at the end of the reporting period.

RESBY93 First generation progeny of adult, residual sockeye salmon captured in Redfish Lake in 1993. Progeny were produced from spawning that occurred at the Eagle Fish Hatchery in 1993. The January 1, 1996 initial inventory was 33 fish. Of these, 23 were released to Redfish Lake on October 7, 1996. One female was used for spawning as described above. Circumstances of mortality for the remaining fish are described in Table 1. At the end of the reporting period, no fish remained in this broodstock.

OMBY93 First generation progeny of female 1991 Redfish Lake outmigrants and the six male sockeye salmon that returned to Redfish Lake Creek in 1993. Parents were crossed to produce 45 unique subfamilies. The January 1, 1996 initial inventory was 111 fish. Of these, 55 matured in 1997. Seventeen of the 55 did not produce viable gametes and were not used for spawning. On September 9 and 10, 1996, four pre-spawn adults (two-pair) from this broodstock were released to Redfish Lake for natural spawning. One individual was implanted with an ultrasonic transmitter to track movement and identify site fidelity and spawning-related behavior. On December 17, 1996, 20 fish from this broodstock that did not mature in 1996 were transferred to the NMFS Big Beef Creek Fish Hatchery in Washington State. Circumstances of mortality for this group are presented in Table 1. At the end of the reporting period, 20 fish remained on-station at Eagle.

ANBY93 First generation progeny of the two female and six male sockeye salmon that returned to Redfish Lake Creek in 1993. Parents were crossed to produce 12 distinct subfamilies. The January 1, 1996 initial inventory was 515 fish. Of these, 154 were incorporated in 1996 spawning efforts at the Eagle Fish Hatchery. On September 9 and 10, 1996, 36 pre-spawn adults (18 pair) from this broodstock were released to Redfish Lake for natural spawning. Four individuals were implanted with ultrasonic transmitters to track movement and identify site fidelity and spawning-related behavior. On December 10 and 17, 1996, a total of 120 fish that did not mature in 1996 were transferred to NMFS facilities in Washington state. Circumstances of mortality for this group are presented in Table 1. One hundred fish remained in this broodstock at the end of the reporting period.

Table 1. Summary of inventory loss for Eagle Fish Hatchery sockeye salmon broodstocks that matured in 1996. Data represents the 1996 calendar year.

	Broodstocks				
	OM93	RESBY92	RESBY93	OMBY93	ANBY93
Starting Inventory (January 1, 1996)	13	3	33	111	515
<u>Mechanical Loss</u>					
Handling	0	0	2	0	3
Jump-out	0	0	0	2	1
<u>Non-Infectious</u>					
Undetermined	1	0	6	10	76
Lymphosarcoma	0	0	0	0	2
<u>Infectious</u>					
Bacterial	0	0	0	0	0
Viral	0	0	0	0	0
Fungal	2	0	0	0	0
<u>Maturation</u>					
Spawners	1	1	1	38	154
Cull	9	2	1	17	23
<u>Relocation</u>					
Transferred	0	0	0	20	120
Released	0	0	23	4	36
Ending Inventory (December 31, 1996)	0	0	0	20	100

Table 2. Summary of inventory loss for Eagle Fish Hatchery sockeye salmon that did not mature in 1996. Data represents the 1996 calendar year.

	Broodstocks				ANBY96
	ANBY94	BY95	Eagle	BY96 Sawtooth	
Starting Inventory (January 1, 1996)	1,111	1,957	0	0	0
<u>Mechanical Loss</u>					
Handling	17	12	0	0	0
Jump-out	0	5	0	0	0
<u>Non-infectious</u>					
Undetermined	63	13	0	0	0
Lymphosarcoma	1	0	0	0	0
<u>Infectious</u>					
Bacterial	0	0	0	0	0
Viral	0	0	0	0	0
Fungal	0	0	0	0	0
<u>Maturation</u>					
Spawners	0	0	0	0	0
Cull	0	0	0	0	0
<u>Relocation</u>					
Transferred	0	0	0	0	440 <sup>a</sup>
Released	0	1,932	0	0	0
Ending Inventory (December 31, 1996)	1,026	0	137,018 <sup>a</sup>	157,983 <sup>a</sup>	1,627 <sup>a</sup>

<sup>a</sup> Eyed-egg numbers.

ANBY94 First generation progeny of the single female sockeye salmon that returned to Redfish Lake Creek in 1994. Males used for spawning crosses in brood year 1994 included first generation progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991 and 1991 Redfish Lake outmigrants. The January 1, 1996 initial inventory was 1,111 fish. Beginning in July 1995, approximately 30% of this broodstock was separated from the general population and placed on a program of reduced feeding (75% of normal broodstock feed rate). At the end of the reporting period, fish receiving normal and reduced rations averaged 1,039 g and 768 g, respectively. Circumstances of mortality for this group are described in Table 2. At the end of the reporting period, 1,026 remained in this broodstock.

BY95 Progeny of one residual sockeye salmon broodstock female (RESBY92) and wild residual males captured in Redfish Lake in 1995. In addition, two female Redfish Lake outmigrants (OM91 and OM93) were crossed with first generation broodstock males produced from the six male and two female sockeye salmon that returned to Redfish Lake Creek in 1993. The January 1, 1996 residual and outmigrant-derived inventory was 1,147 and 810 fish, respectively. All brood year 1995 juvenile sockeye salmon were released from Redfish net pens on October 7, 1996.

BY96 Approximately 109,000 eyed eggs were produced from 1996 spawning efforts at the Eagle Fish Hatchery. As described above, two primary lineage groups (ANBY93 and OMBY93) were used. On December 9, 1996, approximately 29,000 eyed eggs were received at Eagle Fish Hatchery from brood year 1996 spawning activities at the NMFS Big Beef Creek Fish Hatchery in Washington State. Parental lineage for NMFS eggs was similar to that described for Eagle Fish Hatchery eggs. At the end of the reporting period, the Eagle Fish Hatchery was incubating approximately 137,000 eyed eggs from this brood year. In addition, the IDFG Sawtooth Fish Hatchery was incubating approximately 158,000 eyed eggs received from NMFS. Brood year 1996 production at Eagle and Sawtooth fish hatcheries will contribute to 1997 and 1998 fish supplementation efforts. In November 1996, approximately 105,000 brood year 1996 eyed eggs were also transferred from the NMFS Big Beef Creek facility to Redfish Lake for planting in egg boxes. Total brood year 1996 production for IDFG and NMFS facilities was approximately 400,000 eyed eggs.

ANBY96 First generation progeny of the single female sockeye salmon that returned to Redfish Lake Creek in 1996. Males used for spawning crosses included first generation progeny of the two female and six male sockeye salmon that returned to Redfish Lake Creek in 1993 (ANBY93) and one 1993 Redfish Lake outmigrant (OM93). Approximately 2,067 eyed eggs were produced. Of these, 440 were transferred, after eye-up, to the NMFS Big Beef Creek Fish Hatchery in Washington State. On November 7, 1996, cryopreserved milt from the single male sockeye salmon that returned to Redfish Lake Creek in 1992 was used to fertilize four, 30 g sub-lots of eggs produced from three ANBY93 and one OMBY93 broodstock females. Egg numbers averaged approximately 200 per lot. Overall, 4.3% of the eggs successfully fertilized and hatched. At the end of the reporting period, 42 eyed eggs were incubating at the Eagle Fish Hatchery.

### **Fish Health**

Cause of mortality and magnitude of loss for all sockeye salmon broodstocks and production groups maintained at Eagle Fish Hatchery during the term of the reporting period are presented in Tables 1 and 2.

Of the 138 broodstock sockeye salmon examined for viral infection, no cases of infectious hematopoietic necrosis or infectious pancreatic necrosis were documented. One case of cold water disease was documented out of 22 fish examined for myxobacteria and three ELISA optical density (OD) values above background (0.10) were documented for 260 broodstock sockeye examined for BKD (ELISA OD's = 0.121, 0.143, 0.298).

A substantial portion of the fish loss identified in Tables 1 and 2 is classified as "non-infectious undetermined." Necropsies performed on sockeye that contributed to this loss heading generally identified the following clinical signs: swollen kidney, enlarged spleen, mottled liver, petechial hemorrhage in visceral fat, anemia, hemorrhage in posterior intestine, and loss of equilibrium. Occasionally, fish exhibited exophthalmia, darkened body color, and fluid accumulation in the stomach. Mortality generally occurred after sockeye reached approximately 1.5 years in age (approximately 500 g). Histopathology preparations of kidney, spleen, liver, and posterior intestine examined by Elizabeth MacConnell failed to identify cause of death. However, a proliferation of lymphoblasts (lymphoblastosis) was noted in many of the tissue preparations.

Lymphosarcomas (tumors) in adult broodstock sockeye salmon have been observed at the Eagle Fish Hatchery for several years. Similar observations were reported by Meyers and Hendricks (1983) in first generation sockeye salmon adults reared at the Environmental Protection Agency Western Fish Toxicology Laboratory in Corvallis, Oregon. Although the occurrence of this condition in Idaho broodstocks is rare, it is cause for concern and investigation. Typically, tumors occur in the thymic region, causing displacement of the gill arches. To a lesser extent, tumors have developed systemically and occurred in areas near the kidney, spleen, liver, and pseudobranch. During calendar year 1996, three tumors were identified in Eagle Fish Hatchery broodstock sockeye salmon. Two of the tumors occurred in ANBY93 adults, while the third occurred in one ANBY94 adult. Tissue samples and histology preparations sent to Dr. Paul Bowser at Cornell University failed to demonstrate any viral association with lymphosarcomas. Cause has not been determined, but it is doubtful that this condition is infectious.

### **Anadromous and Residual Sockeye Salmon Trapping**

On September 5, 1996, one female anadromous sockeye salmon was captured and transferred to the IDFG Sawtooth Fish Hatchery. The fish measured 49 cm in fork-length and had several external body injuries. No PIT tag was found and no fin clips were present. Following eight days of holding, the fish was transferred to the Eagle Fish Hatchery using a standard transportation tank and auxiliary water as specified in NMFS Permit No. 795. The female was successfully spawned on September 28, 1996.

The adult residual sockeye salmon trap was not installed in 1996.

### **Spawning Activities**

In 1996, 85 brood year 1993 female broodstock sockeye salmon matured and spawned at the Eagle Fish Hatchery between October 3 and November 7. In addition, the one female anadromous sockeye salmon that returned to Redfish Lake Creek matured to spawn on September 28, 1996.

Broodstock spawn crosses followed the spawning matrix developed by IDFG and approved by NMFS (Appendix A). Primary pairings consisted of OMBY93 females with OMBY93 and ANBY93 males and ANBY93 females with ANBY93 males. In addition, one RESBY92 x RESBY93 pairing was made. In all but one case, a minimum of two males was used to fertilize eggs from each female. Pairings were selected to minimize the potential for inbreeding by avoiding partial sibling crosses. We estimated that approximately 41% of brood year 1993 fish (male and female) matured in 1996 and were utilized for spawning or cryopreservation. Broodstock female sockeye salmon produced approximately 180,000 green eggs, for an average fecundity of 2,118 eggs. Final eye-up was estimated at 60.5% (approximately 109,000 eyed eggs) (Figure 2).

The anadromous female sockeye produced approximately 2,067 green eggs. Eggs were divided into five lots and fertilized by a minimum of two males. Males used in spawn pairings including one OM93 male and four ANBY93 males. Final estimated eye-up was 85.0%. Lot isolation was maintained through PIT tagging (approximately 10 g).

### **Pre-Spawn Adult Time on Chilled Water**

Several investigators have suggested upper temperature limits for rearing salmonids to produce high quality eggs and fry. Erdahl (1994) suggested that, for rainbow trout *O. mykiss* broodstock, rearing temperatures not exceed 12°C for at least six months prior to spawning. Swanson (1995) stated that successful reproduction of salmonids in the wild diminishes when water temperature exceeds 13°C.

Post-spawning evaluations at Eagle Fish Hatchery identified no significant differences in mean fecundity, fertilization rate, fish weight, or fish length for brood year 1993 sockeye salmon moved from 13°C rearing water to 10°C chilled water, five and ten months in advance of spawning (Table 3). The mean fertilization rate for fish held on chilled water five months prior to spawning was approximately 5.6 % lower than that for fish held on chilled water for ten months. Nevertheless, results of Student's T tests were not significant. Observed weight and length differences between temperature/time broodstock groups were minimal.

### **Eyed-Egg and Fish Transfers**

On November 14, 1996, IDFG transferred 440 eyed eggs to the NMFS Big Beef Creek Fish Hatchery from the ANBY96 broodstock (see above for additional discussion of this broodstock).

On December 17, 1996, IDFG transferred 20 adults from the OMBY93 broodstock to NMFS facilities in Washington State. The adult transfers increased the spawning selections for fish maturing in the ANBY94 broodstock (fall 1997).

On December 10 and 17, 1996, 120 adults from the ANBY93 broodstock were transferred to NMFS facilities in Washington State.

On December 11, 1996 and January 6, 1997, approximately 158,000 eyed eggs were shipped from NMFS to the Sawtooth Fish Hatchery. Eggs resulted from spawning at the Big Beef Fish Hatchery in Washington State.

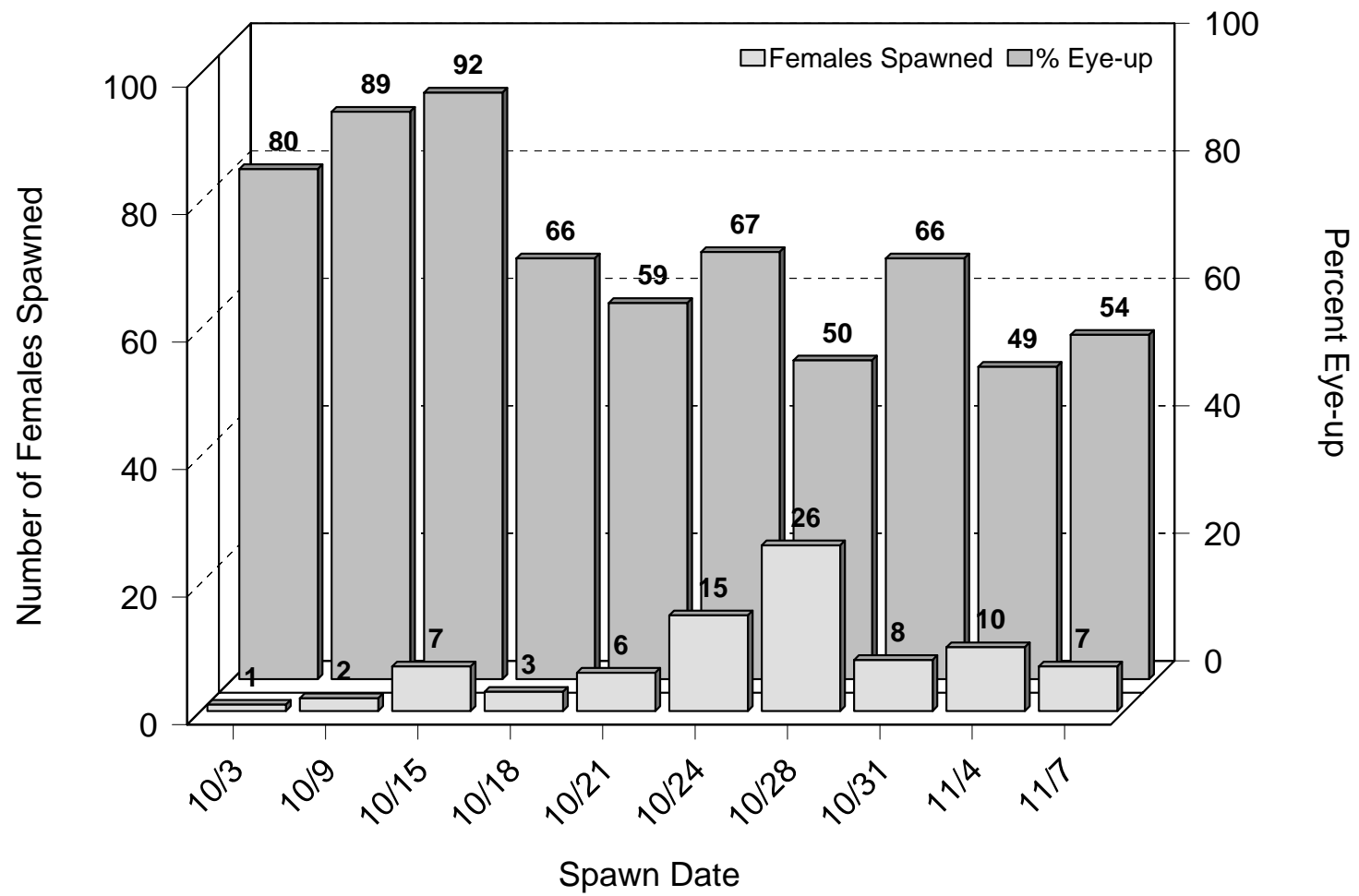




Figure 2. Number of sockeye salmon females spawned and percent eye-up by 1996 Eagle Fish Hatchery spawn date.

Table 3. Summary of spawning data for ANBY93 sockeye salmon moved from 13°C to 10°C water ten and five months in advance of spawning.

Month Moved	N	Mean Fecundity	Mean Percent Eye-up	Mean Weight (g)	Mean Length (mm)
December 1995 <sup>a</sup>	35	2,224.4	61.0	2,266.5	556.9
May 1996 <sup>b</sup>	25	2,193.8	55.4	2,300.2	558.2
Probability Value <sup>c</sup>		0.819	0.574	0.776	0.853

<sup>a</sup> Fish moved to 10°C water in December 1995 (10 months in advance of spawning).

<sup>b</sup> Fish moved to 10°C water in May 1996 (5 months in advance of spawning).

<sup>c</sup> Results of Student's T tests ( $\alpha = 0.05$ ) for spawning variables between December-May groups. No significant differences observed.

### **Eyed-Egg and Fish Supplementation in 1996**

On May 2, 1996, 11,545 age 1+ smolts were released directly to Redfish Lake Creek, downstream of the outmigrant weir. Fish were brood year 1994, second generation progeny of the single female and three male sockeye salmon that returned to Redfish Lake Creek in 1991. Broodstock parents were spawned at the NMFS Big Beef Creek Fish Hatchery and juveniles reared at the Bonneville Fish Hatchery (Oregon Department of Fish and Wildlife). Juveniles returned to Idaho had BKD ELISA OD values of less than or equal to 0.2.

On October 7, 1996, 1,932 brood year 1995 juvenile sockeye salmon were released to Redfish Lake from net pens. The release consisted of 1,168 residual and 764 outmigrant broodstock progeny. All fish were adipose fin-clipped and PIT-tagged (by lineage) for evaluation purposes. Mean weights at tagging (June 26) and release were approximately 8 g and 22 g, respectively.

In September 1996, 120 adult broodstock fish (60 pair) were transported to Redfish Lake from IDFG and NMFS facilities to volitionally spawn. Twenty pair (40 fish) originated from the Eagle Fish Hatchery and were transported and released on September 9 and 10. The remaining 40 pair (80 fish) originated from NMFS facilities in Washington State and were transported and released on September 10. Two lineages were represented in the releases: ANBY93 and OMBY93. All fish were adipose fin-clipped and PIT-tagged. Fifteen females were fitted with ultrasonic transmitters.

In November 1996, approximately 105,000 eyed eggs (brood year 1996) were transferred from the NMFS Big Beef Creek facility to Idaho. Eggs were placed in incubation boxes and planted in Redfish Lake on three dates. Each in-lake incubator received approximately 5,000 eggs (21 total incubators). Incubators were positioned on Sockeye Beach and at the southeast corner of the lake.

### Cryopreservation

On November 7, 1996, cryopreserved milt from the single male sockeye salmon that returned to Redfish Lake Creek in 1992 was used to fertilize four, 30 g sub-lots of eggs produced from three ANBY93 and one OMBY93 broodstock females. Egg numbers averaged approximately 200 per lot. Overall, 4.3% of the eggs successfully fertilized and hatched. At the end of the reporting period, 42 eyed eggs were incubating at the Eagle Fish Hatchery.

On November 5 and 8, 1996, milt from mature, brood year 1994 sockeye salmon was cryopreserved at the Eagle Fish Hatchery. On October 29 and November 5, 1996, milt from this same brood year was harvested at the Eagle Fish Hatchery and shipped (by air) to WSU and UI, where it was cryopreserved the same day. Among facilities, milt from a total of 29 and 10 ANBY93 and OMBY93 males, respectively, was cryopreserved.

On December 19, 1996, we conducted fertilization trials using cryopreserved milt from ANBY93 and OMBY93 broodstock sockeye salmon and fresh milt and eggs from Lake Pend Oreille kokanee collected at the Granite Creek fish trap. Cryopreserved milt used for fertilization trials was preserved at the Eagle Fish Hatchery on November 5 and 8, 1996 and at WSU and UI on October 29 and November 5, 1996. Control fertilization rates for fresh kokanee milt and eggs averaged 89.5%, 94.6%, and 25.2% for Eagle Fish Hatchery, WSU, and UI trials, respectively. Fertilization rates using milt preserved at the Eagle Fish Hatchery on November 5 and 8, 1996 and fresh kokanee eggs averaged 6.8% and 25.0%, respectively. WSU and UI mean fertilization rates using milt from male donors cryopreserved at their facilities averaged 23.7% and 50.4%, respectively (Table 4).

Table 4. Results of 1996 cryopreservation trials conducted at Eagle Fish Hatchery, Washington State University (WSU) and University of Idaho (UI). Mean fertilization rate and fertilization range reflect trials conducted with cryopreserved sockeye salmon milt and fresh kokanee eggs. Fertilization control reflects control trial data using fresh kokanee milt and eggs.

Facility and Trial Date	N	Mean Fertilization Rate (%)	Fertilization Range (%)	Fertilization Control (%)
Eagle, 1995 <sup>a</sup>	17	3.4%	0.0-9.5%	4.8%
Eagle, 11/5/96 <sup>b</sup>	5	6.8%	0.0-16.5%	89.5%
Eagle, 11/8/96 <sup>c</sup>	5	25.0%	20.0-36.4%	89.5%
WSU <sup>d</sup>	10	23.7%	0.0-38.9%	94.6%
UI <sup>d</sup>	7	50.4%	42.1-62.4%	25.2% <sup>e</sup>

<sup>a</sup> Results of 1995 fertilization trials conducted at Eagle Fish Hatchery.

<sup>b</sup> Results of November 5, 1996 fertilization trials conducted at Eagle Fish Hatchery.

<sup>c</sup> Results of November 8, 1996 fertilization trials conducted at Eagle Fish Hatchery.

- <sup>d</sup> Results of September 29 and October 5, 1996 fertilization trials conducted at WSU and UI.
- <sup>e</sup> UI control trial data reflects procedural errors.

### Live Feed Training of Brood Year 1995 Sockeye Salmon Juveniles

Following 12 weeks of rearing experimental groups of live feed-trained and untrained brood year 1995 juvenile sockeye salmon in Redfish Lake net pens, we determined that feed training resulted in significant differences in growth. In all cases, fish that were not feed-trained grew more than fish that were feed-trained. Significant differences were observed in both length and weight gain (Table 5). The results of this experiment were counter-intuitive to what might be expected. Fish that did not receive live prey items during culture prior to release to net pens experienced greater length and weight gain than fish that received live prey items. While this may have been the case with juvenile sockeye salmon in this experiment, Maynard et al. (1996) determined under laboratory conditions that live feed-trained juvenile chinook salmon *Oncorhynchus tshawytscha* consumed twice the live prey as untrained fish.

No assessment was made to determine the amount or type of food organisms available during net pen rearing. However, *Daphnia* is the preferred prey of sockeye juveniles in Redfish Lake. It is possible that prey items presented during training did not resemble available prey enough to cause a recognition response from the juveniles while in net pens. It is also possible that fish became conditioned to eat only those items made available to them during training.

We were able to conduct this experiment due to the relatively few fish that were available for supplementation in 1996. We do not recommend live feed training as a tool to improve growth and/or quality of hatchery-produced sockeye salmon due to the results of this experiment combined with logistic problems associated with applying this technique on a larger scale.

Table 5. Weight and length gain of live feed trained and untrained sockeye salmon experimental groups at release from Redfish Lake net pens.

	N	Weight Gain (g)	Length Gain (mm)
Untrained Group <sup>a</sup>	30	8.6	24.2
Live Feed-Trained Group <sup>b</sup>	27	6.1	17.1
Probability Value <sup>c</sup>		<0.01	<0.01

<sup>a</sup> Experimental group receiving no live prey feed training prior to release to net pens.

<sup>b</sup> Experimental group receiving *Artemia* nauplii and other prey items prior to release to net pens.

<sup>c</sup> Student's T test results ( $\alpha = 0.05$ ) of weight and length gain by experimental group. In both cases findings were significant yet counter-intuitive.

## **ACKNOWLEDGMENTS**

We wish to thank the members of the SBSTOC for their involvement and input throughout the year.

Thanks to all the personnel at the Sawtooth facility. The logistics of this project are sometimes a nightmare and they make each trip (scheduled or spontaneous) much more enjoyable and productive. Special thanks to Brent Snider and Doug Cutting for their extra help during the field season.

Thanks to Russ Kiefer and crew for their help with trapping and field operations.

Thanks to Rick Holm for word processing time and assembling the final report.

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## **APPENDICES**

Appendix A. Idaho Department of Fish and Game 1996 broodstock spawning matrix.

Idaho Department of Fish and Game  
Eagle Fish Hatchery  
1800 Trout Rd.  
Eagle, ID 83616  
(208) 939-4114 fax (208) 939-2415

## MEMORANDUM

To: Drs. Robin Waples, Matt Powell, SBSTOC members.

From: Keith Johnson, IDFG Eagle

Subject: BY96 mating matrix for fish at Eagle with anadromous adults returning in 1996 added.

Maturation in captive broods for 1996 should give us plenty of opportunity for out-crossing between parental origins. It will be complicated to track groups through release, but that is still the goal. Planning will make it flow more smoothly and that is why I am starting this process early. Maturity is expected in the following:

<u>STOCK</u>	<u>CROSSES</u>	<u>NUMBER</u>
BY93	A1,A2,A3,A4,A5,A6	270
	B1,B2,B3,B4,B6	230
	Om x AN 1,2,3,4,5,6	110
OM93	?	13
BY94	AN x BY91, AN x OM	40
RESBY92		1
RESBY93	A1, A2	29

Ground Rules: Maximize diversity, minimize inbreeding through crosses between BY and OM, different BY's, different female and male origins. Residual stocks mated within type.

Appendix A. Continued

Prioritized Spawning Matrix For BY96 at Eagle Fish Hatchery

	FEMALES				
	BY93 Crosses			OM93	BY94
	A	B	OMxAN		
<u>MALES</u>					
BY93 A	no	any	any	any	any
BY93 B	any	no	any	any	any
OM x AN	any	any	no	any	any
OM93	any	any	any	no	any
BY94	any	any	any	any	no

Prioritized Spawning Matrix For BY96 Residuals at Eagle Fish Hatchery

	FEMALES	
	RESBY92	RESBY93
<u>MALES</u>		
Wild	any	any
RESBY92	no	any
RESBY93	any	no

I realize this is getting complex, but we need to plan space, water, incubation temperature, layout, rearing space and location, etc to plan to see if there will be any space for BBC eggs at Eagle. Each of the any listed above could be further prioritized and will be in practice. Again, the goal will be to follow each major genetic group through to release with PIT tags. I expect the major genetic groups to be as follows (female listed first):

BY x BY, OM x OM, By x OM, OM x BY, Residual

I hope we can discuss this topic at the SBSTOC meeting in August and I expect Flagg will have the same topic soon.

Spawning of Anadromous Adults Returning in 1996

Now that it is late July and there are three adult sockeye counted over Lower Granite Dam (wild fish which outmigrated in 1994), we need to consider how to spawn them if they are trapped. Consider: 1) the event of a single adult of each sex; 2) more than one adult but of the same sex; 3) more than one adult, but with maturity which is not synchronous; and 4) more than one adult of both sexes with synchronous maturity.

## Appendix A. Continued

Choices for matings under the above options should consider how well represented the mates are in the captive broodstock already, the number of parents which contributed to the captive broodstock, and can we use parental identity to maximize diversity without increasing inbreeding. Anadromous adults returning in 1996 should be BY92 of residual origin since the sole sockeye returning in 1992 (Larry) was taken into captivity. No smolts trapped in 1994 were retained for captive broodstock.

### **Female Only or Asynchronous**

Divide eggs into four equal lots. Fertilize each lot with two males of the following origin:

OM93, OM x AN, BY93, AN(A) x AN(1,2,3)BY93, AN(B) x AN(4,5,6)BY93

Incubate separately. Provide 150 eyed eggs to NMFS from each of the four groups. Rear to PIT tag size at Eagle. Take 150 of each group for captive broodstock at Eagle and release the remainder to Redfish Lake under the best release strategy.

### **Male Only or Asynchronous**

Fertilize eggs of two females from each of the following:

OM93, OM x ANBY93, AN(A) x AN(1,2,3)BY93, AN(B) x AB(4,5,6)BY93

Incubate separately. Provide 100 eyed eggs to NMFS. Rear to PIT tag size at Eagle. Take 75 progeny of each of the eight crosses for captive broodstock at Eagle. Release the remainder to Redfish Lake under the best release strategy.

### **Female and Male Synchronous**

Divide eggs into four equal lots. Fertilize eggs with two males (one for anadromous male if only one) from each of the following:

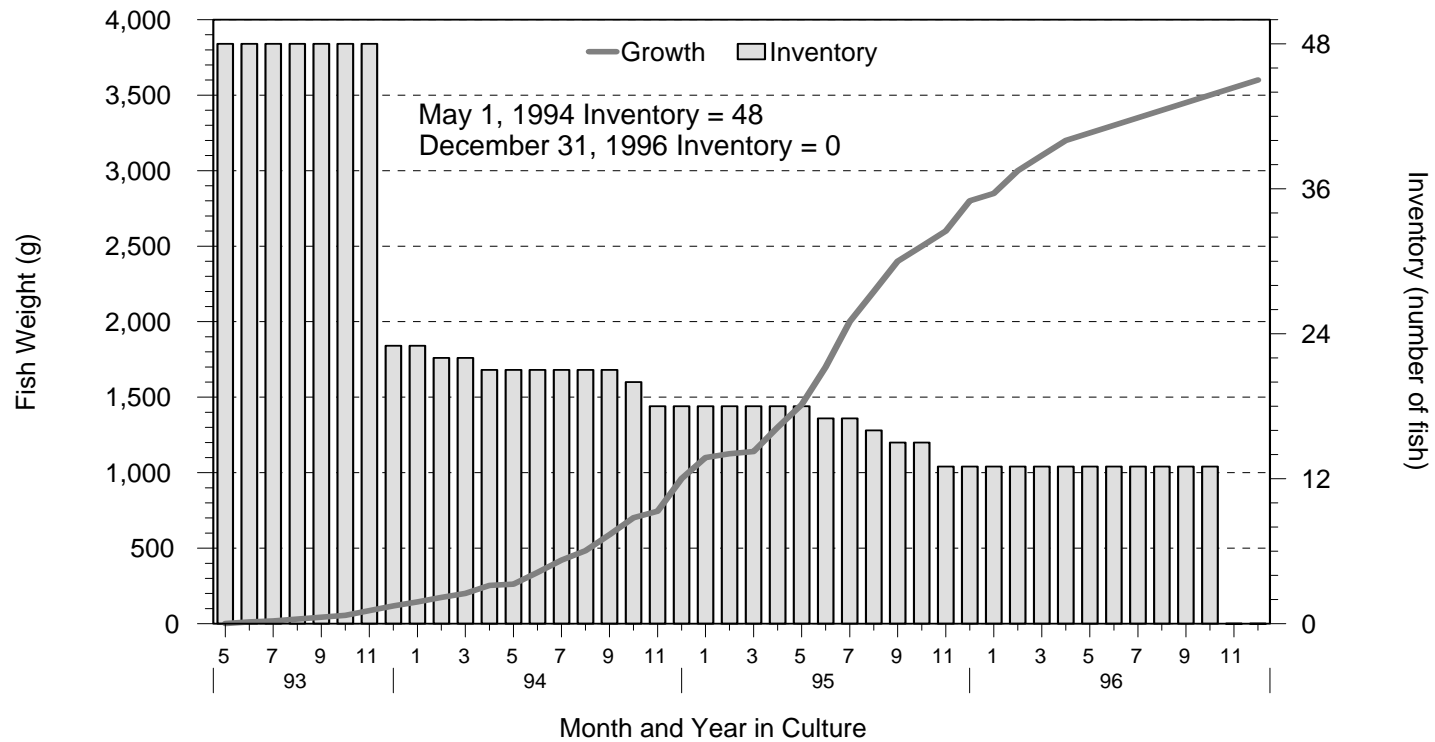
AN, OM93, AN(A) x AN(1,2,3)BY93, AN(B) x AN(4,5,6)BY93

Incubate separately. Provide 150 eyed eggs to NMFS. Rear to PIT tag size at Eagle. Take 150 progeny of each of the four crosses for captive broodstock at Eagle. Release remainder to Redfish Lake under the best release strategy.

Cryopreserve large quantity of sperm from all AN males.

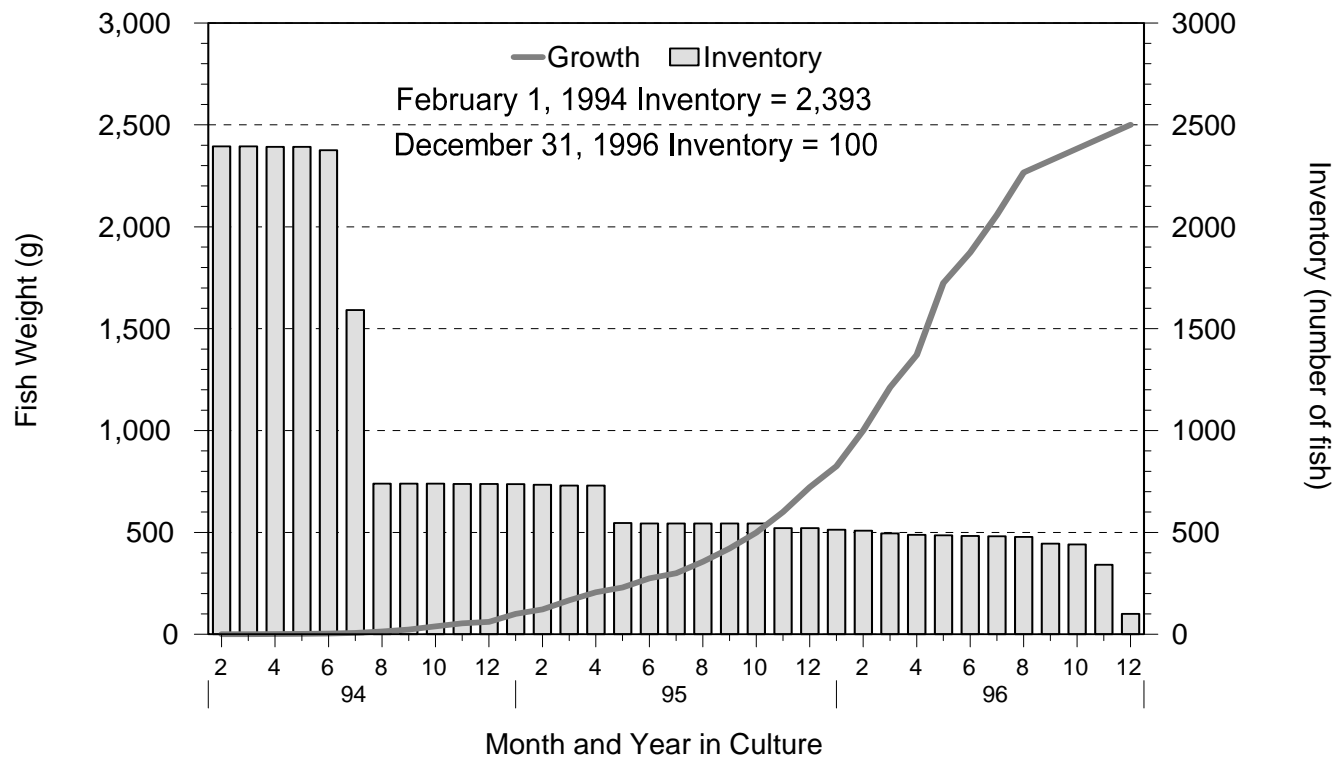
Please look this proposed draft over before the August SBSTOC meeting. Call me with questions or suggestions. I think I can recall the “logic” to this. I will be back to Eagle on August 14 after the Middle Fork trip.

Appendix B. Growth in terms of weight and inventory of selected broodstocks of sockeye salmon at Eagle Fish Hatchery.



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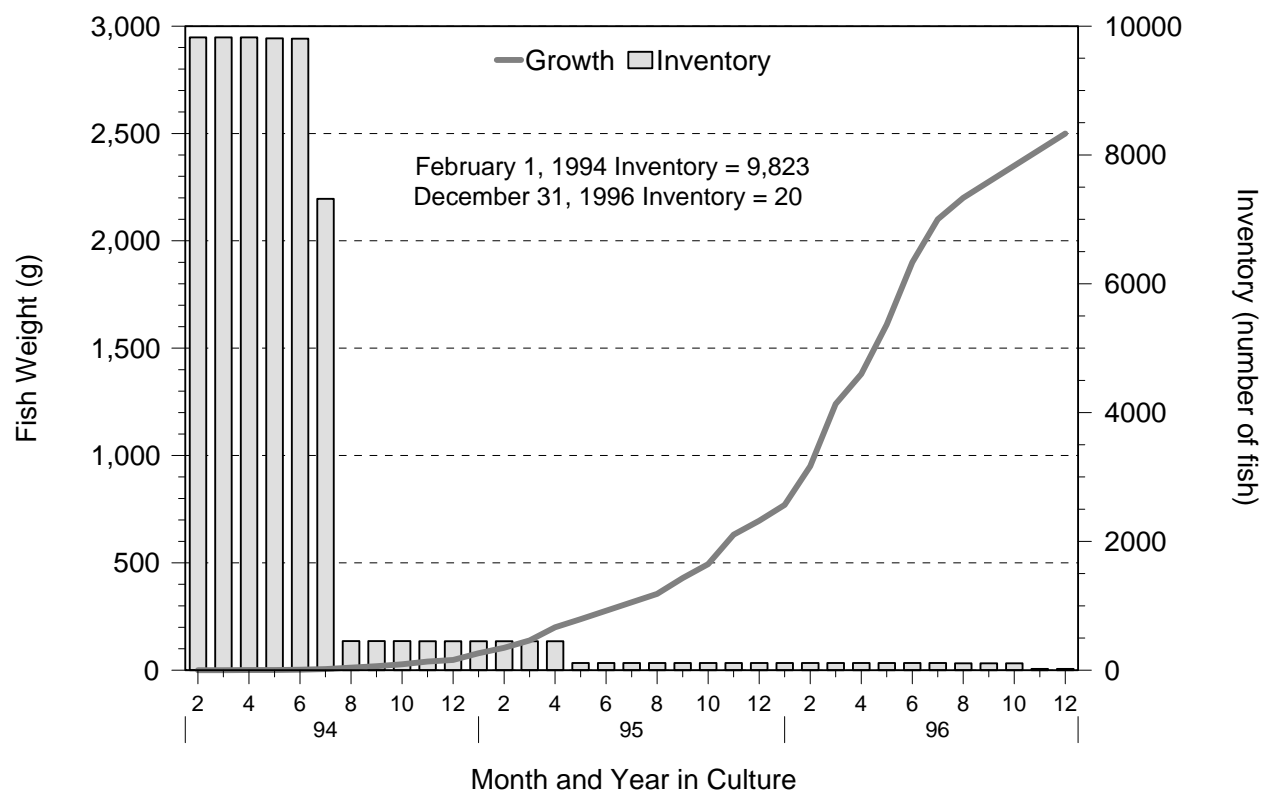
Figure B1. Growth in terms of weight (Y1 axis) and inventory (Y2 axis) of OM93 sockeye salmon from May 1, 1993 through December 31, 1996 at Eagle Fish Hatchery.



2 Appendix B. Continued.  
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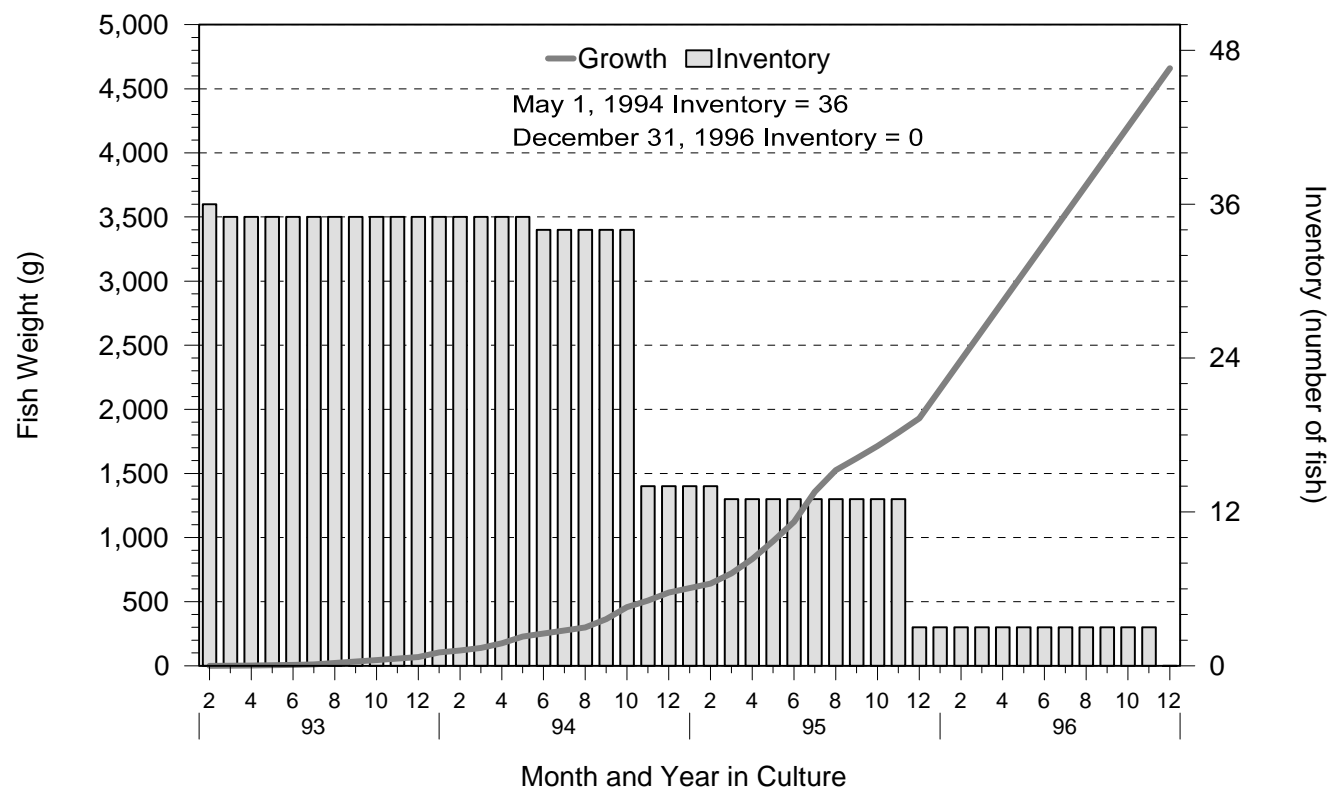
Figure B2. Growth in terms of weight (Y1 axis) and inventory (Y2 axis) of ANBY93 sockeye salmon from February 1, 1994 through December 31, 1996 at Eagle Fish Hatchery.

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Appendix B. Continued.

Figure B3. Growth in terms of weight (Y1 axis) and inventory (Y2 axis) of OMBY93 sockeye salmon from February 1, 1994 through December 31, 1996 at Eagle Fish Hatchery.



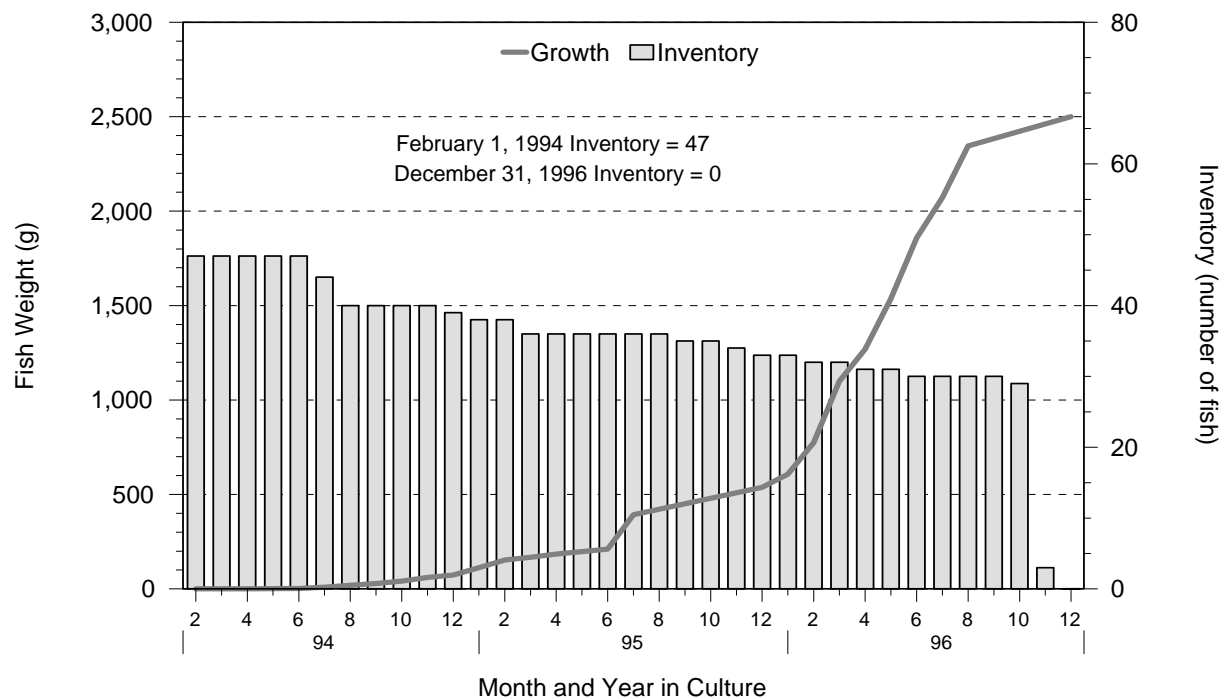
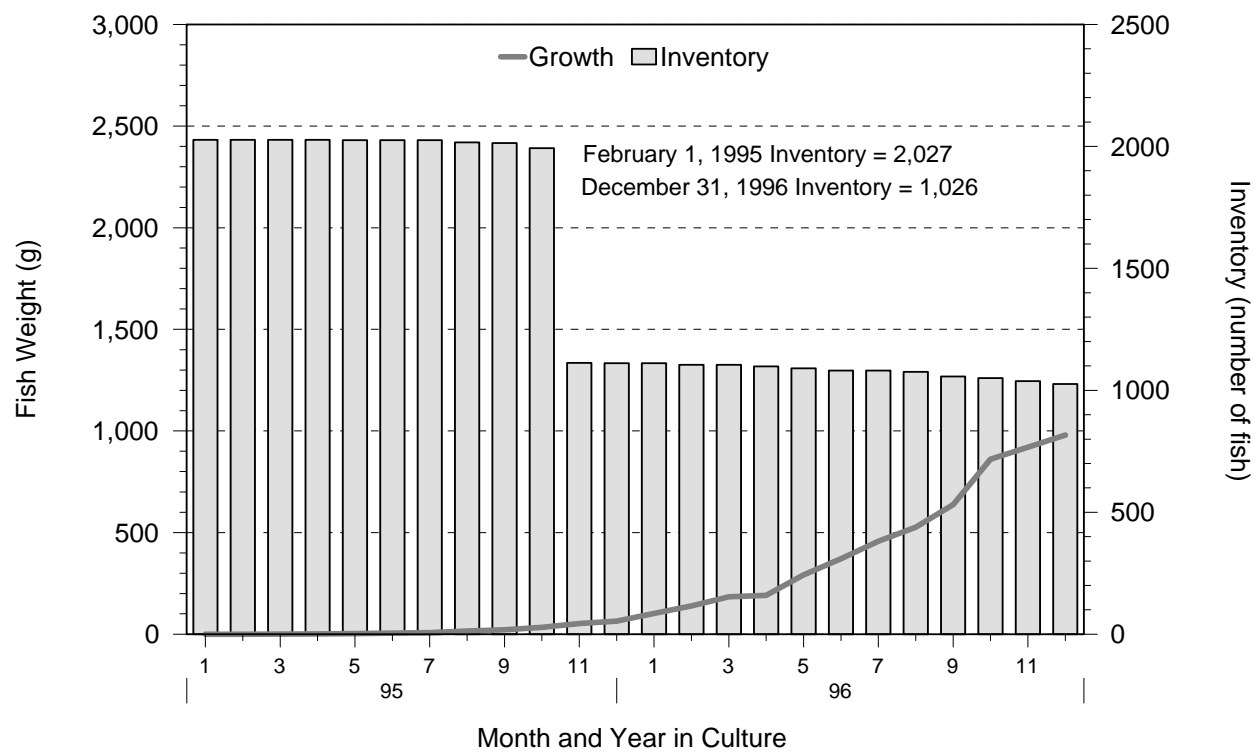


Figure B4. Growth in terms of weight (Y1 axis) and inventory (Y2 axis) of RESBY92 sockeye salmon from February 1, 1993 through December 31, 1996 at Eagle Fish Hatchery.

Appendix B. Continued.

Figure B5. Growth in terms of weight (Y1 axis) and inventory (Y2 axis) of RESBY93 sockeye salmon from February 1, 1994 through December 31, 1996 at Eagle Fish Hatchery.

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Appendix B. Continued.

Figure B6. Growth in terms of weight (Y1 axis) and inventory (Y2 axis) of ANBY94 sockeye salmon from February 1, 1995 through December 31, 1996 at Eagle Fish Hatchery.

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